The correlation between electrical pressure and radius of electrodes distance and voltage nanofiber with different

العلاقة بين الضغط الكهربائي ونصف قطر الليف النانوي مع مسافة الاقطاب والفولتية

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ABSTRACT

The present work is a theoretical study of electrodes distance and the voltage which affected on the fiber formation of polymer type (Poly Ethelene Oxide) [PEO] with assisted electrospinning process, The relations of these parameters with ions electrical pressure(electrical charges forces with respect to area(Nt/m^2)) and the radius of the jet, The solution polymer are tested systematic for production nanofiber with different electrodes distances(2,4,6,8)cm in the systematic, and different voltage from (1-30)KV and Using Matlab program to find the results.

الخلاصة

تمت في هذا البحث دراسة نظرية لبعض العوامل المؤثرة في تكوين الالياف النانوية للبوليمرات من نوع(Poly Ethelene Oxide[PEO]) الذي تم تحضيره بإستعمال طريقة البرم الكهربائي،حيث تم دراسة العوامل (المسافة بين الاقطاب والفولتية) وتأثيرها على الضغط الكهربائي ونصف قطر المقذوفة التي تؤثر على تكوين الالياف النانوية للبوليمر وان محلول البوليمر هو منظومة اختبارية لأنتاج الألياف النانوية لمسافات أقطاب مختلفة (2و4و6و8)سم وبمدى فولتية (1-30)كيلوفولت بألإستعانة ببرنامج مكتوب بلغة الماتلاب لإيجاد النتائج،حيث تبين ان تأثر الياف البوليمر النانوية يكون بشكل مباشر مع زيادة الفولتية وذلك لإزدياد تشوه قطرة البوليمر بين الاقطاب اضافة الى ان زيادة المسافة بين الاقطاب تؤثر في الجهد الكهربائي المؤثر في تكوين الياف البوليمر وتم الاستعانة بنموذج الحالة المستقرة لـ(Spivak) والتي تشمل دالة اتزان الكتلة ودالة اتزان الزخم الخطي اضافة الى معادلة اتزان الشحنة فتم التوصل الى معادلة الضغط الكهربائي ومعادلة نصف قطر المقذوفة.

INTRODUCTION

The Electrohydrodynamic transport phenomena were very important to study many fundamental of different science applied such as electro kinetic technetium, electroionization, electrostatic printing and spinning. Un stable polymer solution is applied in applications (e.g. in mixings), the prefer state is a stable polymer typically the (e.g. in assay and ionized) [1]. Electrohydrodynamic process is the concept of a gasassisted polymer melt electrospinning process is presented by using many theoretical studies. This procedure made reduce the melt jets in the spinning area [2].

Formhals was invente Electrospinning process in (1934), electrostatic force is the base in an experimental setup which made for production the polymer fiber. When Electrospinning use to spining the fiber by that way,the processes is term as electrospinning. electrospinning is a processing to find and create nanofibers with assisted electrically charge jets of polymer solutions or polymer solution[3].Electrospinning make a fundamental various closes to nanofiber production by electrical force to modified formation of the nanofiber procedure. The thought going back at end sixty year [4]. On the other side, the processing which transfer the solution of polymer to nano fiber and diameter to(20-500nm). the spinning process consist from inject the charge inside the polymer fluid. An external electrical field makes a force bigger than the surfacetension for the solution [5] of fluid, causing the eject which accelerate a charges polymer solution jets. charge density reduced is made from the creat surface area as the extend the cylindrical fluid jet and causes diameter reduce to make a nano diameter of the fiber which weave deposit matt on a planar [5].In electrospinning, a polymer solution is keeping electrically charged by high voltage to make cone-like (figure1) protuberances at the liquid-air interface. Increasing voltage further, one reaches a moment when the electrostatic force exceeds the surface tension, and a protuberance transforms into a spike to form a jet [6], [3].

Basic concepts and theories on electrospinning:

The model of steady state jet in the electrospinning process was established by Spivak et al [7],[8]

1- Masses balance equation can be written as:-

$$\boldsymbol{\nabla}.\boldsymbol{u} = \mathbf{0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(\mathbf{1})$$

2-the Linear of momentum balance equation written as:-

$$\rho(\boldsymbol{u}.\boldsymbol{\nabla})\boldsymbol{u} = \boldsymbol{\nabla T^{m}} + \boldsymbol{\nabla T^{e}} \ldots\ldots\ldots(\mathbf{2})$$

3-Electric charge balance read

$$\boldsymbol{\nabla}.\boldsymbol{J} = \mathbf{0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(\mathbf{3})$$

Where $\mathbf{u}$ is the axial drift velocity and $\mathbf{T^m}$, $\mathbf{T^e}$ are viscous forces and electric forces, respectively. ρ the density of the solution, and $\boldsymbol{J}$ the current density.

The charges inside the solution make the electrostatic pressure for the solution and change the shape of the drops , then produced of the jets . one can calculate this when the equation of poisson for equipotential plane is solved by using equation (3) and from the curvature of the surface can be determined [9]:-

$$\boldsymbol{P_E} = \mathbf{0.5}\boldsymbol{\varepsilon_o E^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(\mathbf{4})$$

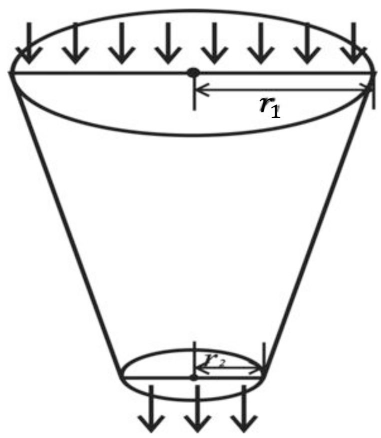
Where $\boldsymbol{P_E}$ is the electrical pressure, $\boldsymbol{\varepsilon_o}$ is the vacuum permittivity, $\boldsymbol{E}$ the electrical field

The radius of the jet

From the conservation of mass, the radius of the jet must be known [10]:-

$$\boldsymbol{\pi r^2 \rho u} = \boldsymbol{Q} \ldots\ldots\ldots\ldots(\mathbf{5})$$

Where $\boldsymbol{r}$ the radius of the jet $\boldsymbol{\rho}$ the density of the polymer $\boldsymbol{Q}$ is the flow rate:-



Figure(1):cone-like protuberances at the liquid-air interface for polymer liquid[10]

Assume that the current and the volume flow rate of the polymer solvent $(\boldsymbol{Q})$ were fixed with the electrospinning then the radius of the jet will be constant and

$$\boldsymbol{Q} \propto \boldsymbol{r}^{\boldsymbol{0}}$$

Then the radius become

$$\boldsymbol{r} = \sqrt{\frac{\boldsymbol{1}}{\boldsymbol{\pi u \rho}}} \dots\dots\dots\dots\dots..(\boldsymbol{6})(\boldsymbol{Q} \approx \boldsymbol{1})$$

In the present work, the polymer of [PEO](Poly Ethelene Oxide) will investigated by electrospinning to product nanofiber with voltage range from(1-30)KV in the room temperature and with distance between electrodes(2,4,6,8,)cm.

RESULTS AND DISSCUSSION:

Many of parameters which effect on the Electrohydrodynamic and then the type of fiber production depending on these parameters, for a fluid, the electrical field and the shape of jet affected by flow rate. then the electrical field is increased make the jet change more rapidly because increasing the energy of the charges and the conical region become shorter than and more concave in profile [10],[9] for example parameter one can reduction the diameter from 35 ± 8 μm, to 840 ± 190 nm with a viscosity-reducing additive. Solvent electrospun tend of Poly(ethylene glycol) block poly(ε-caprolactone) (peg47 b pcl95)and poly(ε- caprolactone)(pcl) production the fiber and the radius with micron scale(2.0±0.3) [11] .

The relationship between Electrical pressure inside the fiber and distance of the electrical electrodes (equation (4) which the electrical field depend on the distances of electrodes) . For different voltage (figure 2) one can see the direct effect for the distance on the electrical pressure. Since when the distance increased the pressure decrease because the electrical field decrease when the distances increases [12] [13]. this can be directly understood from the equation (4).for different voltage one can find different electrical pressure and different structure of nanofiber.

Figure(3) shows the correlation of the electrical pressure with different voltage. One can notice that the low voltage may be effected on the electrical field and the charges energy inside the fiber and this give low values of the electrical pressure [14]. when the voltage increased this causes the increase in the electrical pressure and as we believe that higher energy inside the fiber which causes to tensile the drops from the jet which make affected on the formation of the nanofiber. from figure(3) when the distances of electrodes increased one can conclude that it is affected on the attenuation of the charges energy, then the electrical pressure decreases [14] .From the figures(2,3) using different voltages and different distances that change nanofiber and one can find optimum parameters for the nanofiber characteristics. The jet radius related with electrodes distances as shown in figure (4). This figure demonstrate the reduction in the radius values which related with the electrode distances in small distances the charges have high speed because the kinetic energy of this charges very high compared with large distances. Due to the small distances, the electrical fields higher than the larges distances and this causes reducing in the radius of the jet. in increasing voltage we decreased in the levels of the radius, this results corresponding with many researches [15],[16].in the other hand one can see the effect of the high voltage in the figure (5) which illustrate the correlation between the radius of the jet and the distances. From this figure the general behavior of the jet radius for each high voltage is increased as the distance between electrodes increased because the distance makes high electrical field and then small radius. The results of this works are corresponding with many researches [2],[17],[18],[11]

Conclusion:-

From the results, the formation of nanofibers were strongly depending on the distance between the electrodes which increasing the electric field and make nanofiber with small radius and strong electrical pressure, and can be conclude from the fluctuation for the radius as the figure shown that.in the same that the increasing for the voltage make the electric field increasing which direct effect on the nanofiber, from that by using the mathematical model can be conclude optimum nanofiber with special properties for any application which need.

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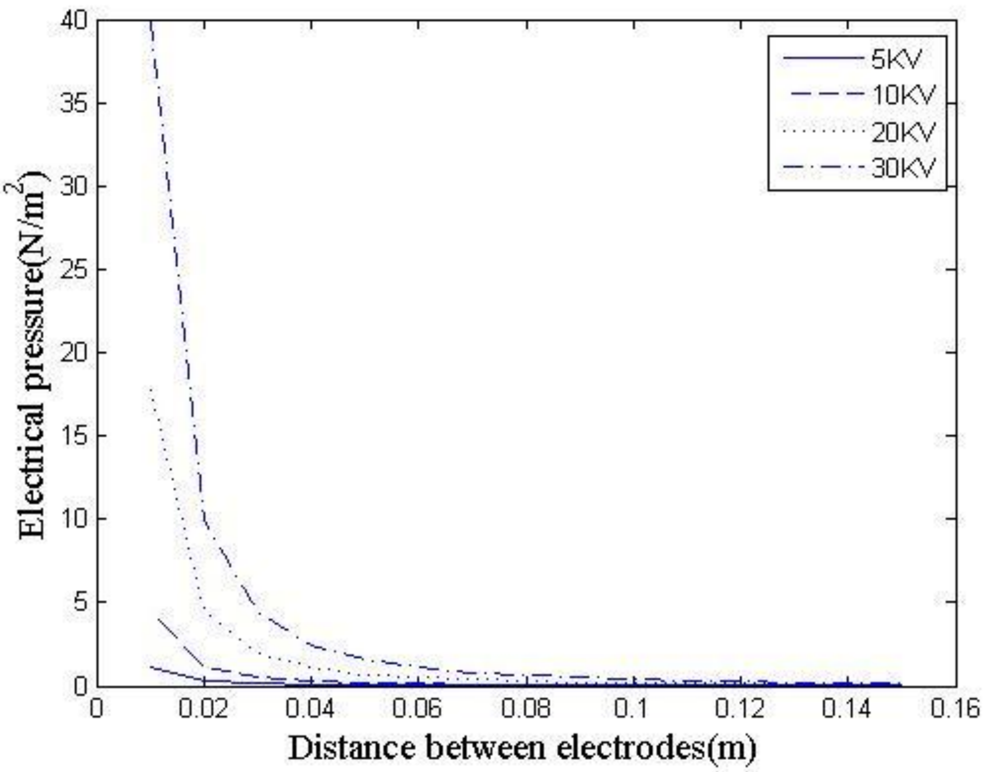
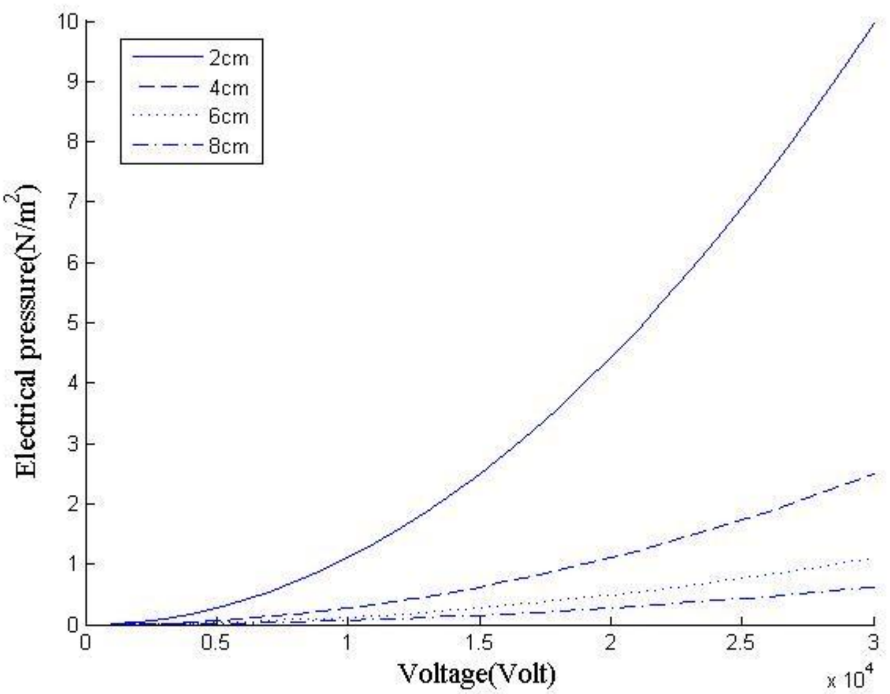


Figure (2):-The relation between Electrical pressure and distances of electrodes for different voltage



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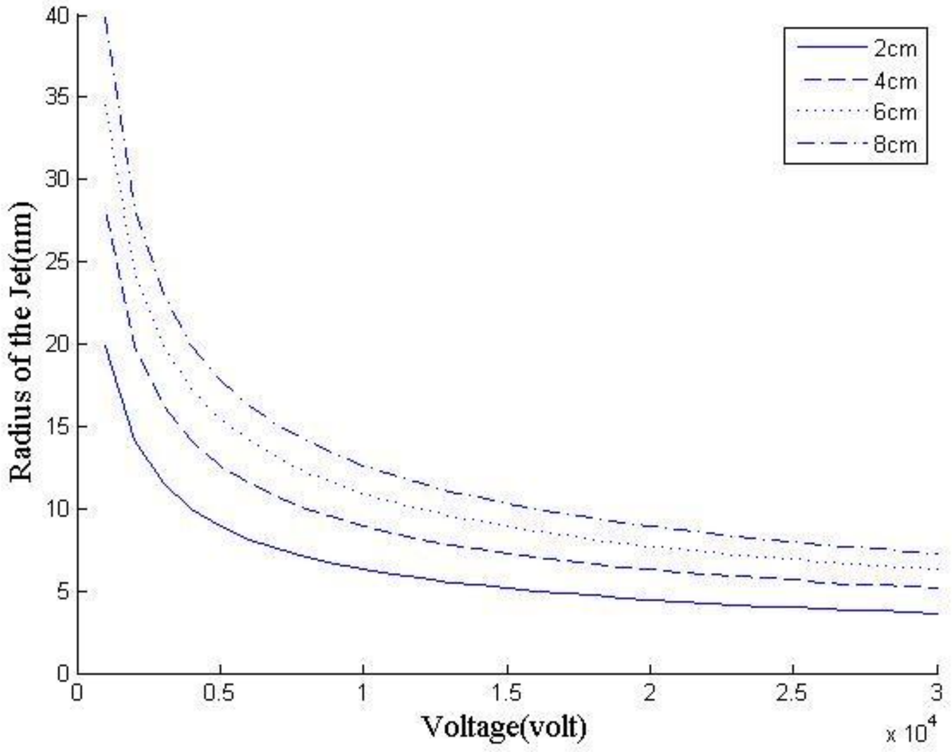

Figure (4):-The Radius of the jet as a function of Voltage for various distances between electrodes

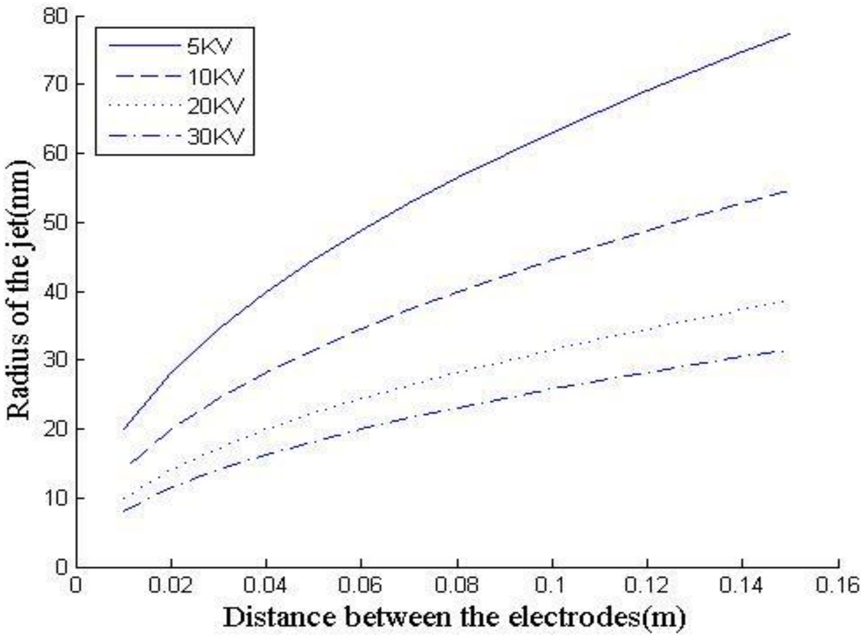

Figure (5):-The Radius of the jet as a function of distance between electrodes for various voltages.